IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Swihart et al.	Examiner: A. Sarkar
Serial No.	:	10/796,442	Art Unit: 2891
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For	:	PROCESS FOR PREPARING LUMINESCENT SILICON NANOPARTICLES	

SECOND DECLARATION OF MARK T. SWIHART, Ph.D., UNDER 37 C.F.R. § 1.132

I, MARK T. SWIHART, Ph.D., hereby declare:

1. I received a Bachelor of Science degree in Chemical Engineering from Rice University in 1992 and a Ph.D. degree in Chemical Engineering from The University of Minnesota, Twin Cities, in 1997.

2. I am currently Associate Professor and Director of Graduate Studies, Department of Chemical and Biological Engineering, at The University at Buffalo (SUNY), Buffalo, New York.

3. I am an inventor of the above-identified application.

4. As indicated in my attached *Curriculum Vitae* (**Exhibit A**), I have authored or co-authored over 75 peer-reviewed professional publications in the field of nanoscale science and engineering and related fields. Since 2000, I have given over 15 invited lectures in these same technical fields.

5. I am a reviewer for *Science*, *Advanced Materials*, *Journal of the American Chemical Society*, *Nano Letters*, *Advanced Functional Materials*, *Chemistry of Materials*, *Langmuir*, *The Journal of Physical Chemistry* (*A* and *B*), *Industrial and Engineering Chemistry Research*, *The Journal of Chemical Physics*, *The Journal of the Electrochemical Society*, *The Journal of Materials Science*, *Chemical Vapor Deposition*, *The International Journal of Chemical Kinetics*, *The Journal of Crystal Growth*, *The Journal of*

Computational Chemistry, *Journal de Physique IV*, *The Journal of Aerosol Science*, *Aerosol Science and Technology*, *The Journal of Nanoparticle Research*, *Surface Science*, *Physica E*, *The Journal of Nanophotonics*, and *Applied Physics A*.

6. A major focus of my research has been in the area of nanoparticle synthesis. As a result of that research and the corresponding publications and lectures, I am regarded as an expert in that field.

7. I understand that the United States Patent and Trademark Office ("PTO") considers that it would have been obvious from Seraphin, "Influence of Nanostructure Size on the Luminescence Behavior of Silicon Nanoparticles Thin Films," *J. Mater. Res.* 12(12):3386 (1997) ("Seraphin") to etch free silicon nanoparticles with hydrofluoric acid ("HF") and nitric acid ("HNO_3") to modify their photoluminescence, and to stabilize the photoluminescence of free silicon nanoparticles by treating them with a chemical oxidizer (*e.g.*, HNO_3). I have reviewed Seraphin and the outstanding office action, and do not believe that these methods would have been apparent to a skilled scientist.

8. Seraphin teaches two methods for modifying the luminescence of thin films of nanoscale silicon thin films: (1) sequential, separate exposures to HF and HNO_3 (Seraphin at 3387, left col., ll. 6–16), and (2) simultaneous exposure to HF and HNO_3 (Seraphin at 3387, left col., ll. 16–19). The methods of my above application would not have been apparent from either of these approaches to a scientist skilled in the field.

9. The PTO has cited page 3387, column 1, of Seraphin as teaching an acid etch solution of about 0.5% to 20% HF and about 10% to 40% HNO_3. It does not. Seraphin teaches etching thin films in 48% HF for 60 seconds and *separately* etching the films in 20% HNO_3 for 10 minutes. The only concentration for *simultaneous* HF/HNO_3 etching taught in Seraphin is a solution of 2% HF, 48% HNO_3, and 50% H_2O. Seraphin does not suggest modifying its solution by adjusting the amount of HF and HNO_3 to the range claimed in my above application.

10. As for acid etching via simultaneous exposure to HF and HNO_3, Seraphin teaches use of a mixture of 2% HF, 48% HNO_3, and 50% H_2O (Seraphin at 3387, left col., ll. 16–19). As shown in Figure 3 of Seraphin, the shift in photoluminescence using this mixture is achieved with an exposure time of 10 seconds. This treatment would not be effective for free silicon nanoparticles, because such short exposure times are not practical for

free particles. For the longer exposure times shown (*i.e.*, 30 and 60 seconds), there is little additional blue-shift of the photoluminescence, and the primary effect is simply a reduction in photoluminescence intensity, which is undesirable. Therefore, a scientist skilled in the field would have concluded that it would be ill-advised to etch with this mixture for longer periods.

11. As described in my above application, tuning of the photoluminescence wavelength for free silicon nanoparticles using a HF/HNO_3 solution is only practical when the nitric acid concentration is reduced or the etching solution is otherwise modified to make the etching process substantially slower than the process taught by Seraphin. Seraphin does not suggest how to modify its solution to make it suitable for etching free silicon nanoparticles, nor would doing so have been apparent to a scientist skilled in the field.

12. Seraphin reports treating agglomerated particles with HNO_3 to produce a surface oxide layer on the particles. However, Seraphin does not create the oxide layer to stabilize the photoluminescence of the particles. Instead, Seraphin produces the oxide layer for the sole purpose of reducing the size of the crystalline silicon core of the particles. As shown in Figure 2 of Seraphin, the oxide layer is immediately removed by a subsequent exposure to HF, in order to further reduce the particle size. Thus, while Seraphin teaches the formation of an oxide layer by exposure to HNO_3, Seraphin does not teach the use of this process to stabilize the photoluminescence. In contrast, Seraphin considers "aging" and HNO_3 treatment to be equivalent means of reducing the size of the silicon core. Seraphin does not even teach treating silicon thin films with a chemical oxidizer to stabilize photoluminescence, let alone to do so with free silicon nanoparticles.

13. The only discussion in Seraphin relating to the stability of photoluminescence is in relation to silicon nanoparticle thin films that are oxidized in air. The photoluminescent peak reportedly remains at a final position after three days of aging, but no data beyond three days is given (Seraphin at page 3387, col. 1, l. 48–col. 2, l. 5, Figure 1). Moreover, while Seraphin addresses the stabilization of photoluminescence wavelength, it does not say anything about the photoluminescence intensity. In contrast, my above application demonstrates that chemically formed oxide produced, *e.g.*, by HNO_3 treatment provides much greater stabilization of the photoluminescence of free silicon nanoparticles

than the "native" oxide that is formed by exposure to room air. In particular, Example 8 and Figures 11A–B of this application show that treating silicon nanoparticles with a chemical oxidizer not only stabilizes the photoluminescent wavelength, but also the intensity. Prior to the work described in my patent application, it was not known, and there was no reason to expect, that treatment with a chemical oxidizer (*e.g.*, HNO_3) would have provided a more protective oxide shell than oxidation in air or other oxidative treatment.

14. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Dated: February _15_, 2007

Mark T. Swihart, Ph.D.

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Curriculum Vitae

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EDUCATION AND EMPLOYMENT

University at Buffalo, State University of New York, Buffalo, NY

Associate Professor, Chemical Engineering, August 2004–present

Assistant Professor, Chemical Engineering, August 1998–August 2004

Research Topics: Synthesis and applications of nanoparticulate materials; Nanoparticle nucleation and growth; Laser pyrolysis for kinetic studies and nanoparticle synthesis; Experimental and theoretical studies of elementary reactions important for vapor phase materials synthesis; Detailed chemical kinetics, fluid dynamics, and aerosol dynamics in high temperature vapor phase materials processing; Applied computational quantum chemistry.

Innovalight, Inc., Minneapolis, MN, Member of Scientific Advisory Board, 2003–present

INCO Technical Services, Ltd., Toronto, Canada, Consultant, 2003–present

University of Minnesota, Minneapolis, MN

Post-Doctoral Research Associate, Mechanical Engineering, August 1997–August 1998

Research Topics: Experimental and modeling studies of particle nucleation, growth and transport in silicon CVD; Modeling of r.f. plasma CVD of oriented diamond films.

Advisors: Steven L. Girshick, Peter H. McMurry, Stephen A. Campbell

University of Minnesota, Minneapolis, MN

Ph.D., Chemical Engineering, July, 1997

Fields of Study: Reaction Engineering, Chemical Kinetics, Mathematical Modeling, Reactive Flows, Chemical Vapor Deposition Processing.

Advisor: Robert W. Carr

Dissertation Title: Gas Phase Chemical Kinetics and the Detailed Modeling of Chemical Vapor Deposition Processes

Rice University, Houston, TX

B.S., Chemical Engineering, *Summa Cum Laude*, May, 1992

HONORS AND AWARDS

Outstanding McNair Faculty Mentor from the University at Buffalo Ronald E. McNair Post-Baccalaureate Achievement Program, 2006.

Licensed Innovation Award from the Research Foundation of SUNY, 2005.

Department of Chemical and Biological Engineering Outstanding Professor Award, 2003, determined by nomination and vote of undergraduates in the department.

J.B. Wagner Young Investigator Award of the High Temperature Materials Division of the Electrochemical Society, 2003. This is an international award presented to only one person every two years.

Promising Inventor Award from the Research Foundation of SUNY, 2003.

Doctoral Dissertation Fellowship, University of Minnesota, 1995–96

National Science Foundation Fellowship, 1992–95

PUBLICATIONS

I. Publications in Refereed Journals:

1) Yong, Ken-Tye, Yudhisthira Sahoo, Mark T. Swihart, and Paras N. Prasad, "Shape Control of CdS Nanocrystals in One Pot Synthesis," *Journal of Physical Chemistry C*, **in press** (2007).

2) Yong, Ken-Tye, Jun Qian, Indrajit Roy, Hoon Hi Lee, Earl J. Bergey, Kenneth M. Tramposch, Sailing He, Mark T. Swihart, Anirban Maitra, and Paras N. Prasad, "Quantum Rod Bioconjugates as Targeted Probes for Confocal and Two-Photon Fluorescence Imaging of Cancer Cells," *Nano Letters*, **in press**, published online Feb. 9, 2007.

3) Zhang, Hongwang and Mark T. Swihart, "Synthesis of Tellurium Dioxide Nanoparticles by Spray Pyrolysis," *Chemistry of Materials*, **111**, 2447–2458 (2007).

4) Yong, Ken-Tye, Yudhisthira Sahoo, Kaushik Roy Choudhury, Mark T. Swihart, John R. Minter and Paras N. Prasad, "Control of the Morphology and Size of PbS Nanowires using Gold Nanoparticles," *Chemistry of Materials*, **18**, 5965–5972 (2006).

5) Sato, Seiichi and Mark T. Swihart, "Propionic acid terminated silicon nanoparticles: Synthesis and optical characterization," *Chemistry of Materials*, **18**, 4083–4088 (2006).

6) Yong, Ken-Tye, Yudhisthira Sahoo, Mark T. Swihart, and Paras N. Prasad, "Growth of CdSe Quantum Rods and Multipods Seeded by Noble Metal Nanoparticles," *Advanced Materials*, **18**, 1978–1982 (2006).

7) Shi, Weili, Yudhisthira Sahoo, Hao Zeng, Yong Ding, Mark T. Swihart, and Paras N. Prasad, "Anisotropic Growth of PbSe Nanocrystals on Au-Fe_3O_4 Hybrid Nanoparticles," *Advanced Materials*, **18**, 1889–1894 (2006), also featured on the inside front cover, *Advanced Materials*, **18** (14), July 18, 2006.

8) Yong, Ken-Tye, Yudhisthira Sahoo, Mark T. Swihart, and Paras N. Prasad, "Synthesis and Plasmonic Properties of Silver and Gold Nanoshells on Polystyrene Cores of Different Size and of Gold-Silver Core-Shell Nanostructures," *Colloids and Surfaces A*, **290**, 89–105 (2006).

9) Shi, Weili, Hao Zeng, Yudhisthira Sahoo, Tymish Ohulchanskyy, Yong Ding, Zhong Lin Wang, Mark T. Swihart, and Paras N. Prasad, "A General Approach to Binary and Ternary Hybrid Nanocrystals," *Nano Letters*, **6**, 875–881 (2006). *Highlighted in Science Magazine's Editor's Choice: Highlights of the Recent Literature column. Science,* **311**, 1675 (March 24, 2006).

10) Yong, Ken-Tye, Yudhisthira Sahoo, Kaushik Roy Chaudhury, Mark T. Swihart, John R. Minter, and Paras N. Prasad, "Shape Control of PbSe Nanocrystals Using Noble Metal Seed Particles," *Nano Letters*, **6**, 709–714 (2006).

11) Hua, Fengjun, Folarin Erogbogbo, Mark T. Swihart, and Eli Ruckenstein, "Organically capped silicon nanoparticles with blue photoluminescence prepared by hydrosilylation followed by oxidation," *Langmuir*, **22**, 4363–4370 (2006).

12) He, Yuanging, Yudhisthira Sahoo, Shumin Wang, Hong Luo, Paras N. Prasad, and Mark T. Swihart, "Laser-Driven Synthesis and Magnetic Properties of Iron Nanoparticles," *Journal of Nanoparticle Research,* **8**, 335–342 (2006).

13) Sahoo, Yudhisthira, Yuanqing He, Mark T. Swihart, Shumin Wang, Hong Luo, Edward P. Furlani, and Paras N. Prasad, "An aerosol-mediated magnetic colloid: Study of nickel nanoparticles," *Journal of Applied Physics*, **98**, 054308 (2005).

14) Khakimov, Z.M., P.L. Tereshchuk, F.T. Umarova, M.T. Swihart, "Non-conventional tight-binding method for calculation of total energy and spectroscopic energies of atomic clusters. Transferable parameters for silicon," *Physical Review B*, **72** 115335 (2005).

15) Hua, Fengjun, Mark T. Swihart, and Eli Ruckenstein, "Efficient surface grafting of luminescent silicon quantum dots by photoinitiated hydrosilylation," *Langmuir*, **21**, 6054–6062 (2005).

16) Kirkey, William D., Yudhisthira Sahoo, Xuegeng Li, Yuanqing He, Mark T. Swihart, Alexander N. Cartwright, Stanley Bruckenstein, and Paras N. Prasad, "Quasi-Reversible Photoluminescence Quenching of Stable Dispersions of Silicon Nanoparticles," *Journal of Materials Chemistry*, **15**, 2028–2034 (2005).

17) He, Yuanqing, Xuegeng Li, and Mark T. Swihart, "Laser-Driven Aerosol Synthesis of Nickel Nanoparticles," *Chemistry of Materials*, **17**, 1017–1026 (2005).

18) Shi, Weili, Yudhisthira Sahoo, Mark T. Swihart, and Paras N. Prasad, "Gold Nanoshells on Polystyrene Cores for Control of Surface Plasmon Resonance," *Langmuir*, **21**, 1610–1617 (2005).

19) Sahoo, Yudhisthira, Alireza Goodarzi, Mark T. Swihart, Tymish Y. Ohulchanskyy, Navjot Kaur, Edward P. Furlani, and Paras N. Prasad, "Aqueous ferrofluid of magnetite nanoparticles: Fluorescence labeling and magnetophoretic control," *The Journal of Physical Chemistry B*, **109**, 3879–3885 (2005).

20) Liu, Gang, Mark T. Swihart, and Sriram Neelamegham, "Sensitivity, principal component and flux analysis applied to signal transduction: The case of epidermal growth factor mediated signaling," *Bioinformatics*, **21**, 1194–1202 (2005).

21) Wong, Hsi-Wu, Xuegeng Li, Mark T. Swihart, and Linda J. Broadbelt, "Detailed Kinetic Modeling of Silicon Nanoparticle Formation Chemistry via Automated Mechanism Generation," *Journal of Physical Chemistry A*, **108**, 10122–10132 (2004).

22) Shi, Weili, Y. Sahoo, and Mark T. Swihart, "Gold nanoparticles surface-terminated with bifunctional ligands," *Colloids and Surfaces, A: Physicochemical and Engineering Aspects*, **246**, 109–113 (2004).

23) Talukdar, Suddha S., and Mark T. Swihart, "Aerosol dynamics modeling of silicon nanoparticle formation during silane pyrolysis: a comparison of three solution methods," *Journal of Aerosol Science*, **35**, 889–908 (2004).

24) Li, Xuegeng, Yuanqing He, and Mark T. Swihart, "Surface Functionalization of Silicon Nanoparticles Produced by Laser-Driven Pyrolysis of Silane followed by HF-HNO_3 Etching," *Langmuir* , **20,** 4720–4727 (2004).

25) Li, Zhifeng, Mark T. Swihart, and Eli Ruckenstein, "Luminescent Silicon Nanoparticles Capped by Conductive Polyaniline through the Self-assembly Method," *Langmuir*, **20**, 1963–1971, (2004).

26) Wong, Hsi-Wu, Juan Carlos Alva Nieto, Mark T. Swihart, and Linda J. Broadbelt, "Thermochemistry of Silicon-Hydrogen Compounds Generalized from Quantum Chemical Calculations," *The Journal of Physical Chemistry A*, **108,** 874–897, (2004).

27) Khakimov, Z.M., P.L. Tereshchuk, F.T. Umarova, and Mark T. Swihart, "Improved Parameterization of Non-Conventional Tight-Binding Method for Simulation of Silicon Nanoclusters," *Uzbek Journal of Physics*, **6**, 264–269 (2004).

28) Li, X., Y. He, S.S. Talukdar and M.T. Swihart, "A process for preparing macroscopic quantities of brightly photoluminescent silicon nanoparticles with emission spanning the visible spectrum," *Langmuir*, **19**, 8490–8496 (2003).

29) Catoire, L., M. T. Swihart, S. Gail, and P. Dagaut, "Anharmonic Thermochemistry of Cyclopentadiene Derivatives," *The International Journal of Chemical Kinetics*, **35**, 453–463 (2003).

30) Nijhawan, S., P. H. McMurry, M. T. Swihart, S.-M. Suh, S. L. Girshick, S. A. Campbell, and J. E. Brockmann, "An Experimental and Numerical Study of Particle Nucleation and Growth During Low-Pressure Thermal Decomposition of Silane," *The Journal of Aerosol Science*, **34**, 691–711 (2003).

31) Wong, H.-W., X. Li, M.T. Swihart, and L.J. Broadbelt, **"**Encoding of Polycyclic Si-Containing Molecules for Determining Species Uniqueness in Automated Mechanism Generation," *Journal of Chemical Information and Computer Sciences*, **43**, 735–742 (2003).

32) Swihart, M.T., "Vapor Phase Synthesis of Nanoparticles" (Invited Review), *Current Opinion in Colloid and Interface Science*, **8**, 127–133 (2003).

33) Swihart, M.T., L. Catoire, B. Legrand, I. Gökalp, and C. Paillard, "Rate Constants for the Homogeneous Gas-Phase Al/HCl Combustion Chemistry," *Combustion and Flame*, **132**, 91–101 (2003).

34) Talukdar, S.S., and M.T. Swihart, "An Improved Data Inversion Program for Obtaining Aerosol Size Distributions from Differential Mobility Analyzer Data," *Aerosol Science and Technology*, **37**, 145–161 (2003).

35) Catoire, L., and M.T. Swihart, "Thermochemistry of species produced from monomethylhydrazine (MMH) in propulsion and space-related applications," *The Journal of Propulsion and Power*, **18**, 1242–1253, (2002).

36) Catoire, L., and M.T. Swihart, "High Temperature Kinetics of $AlCl_3$ Decomposition in the Presence of Additives for Chemical Vapor Deposition," *The Journal of the Electrochemical Society*, **129**, C261–C267 (2002).

37) Jalbout, A.F., Swihart, M.T., and Jursic, B.S., "Corrigendum to "Potential energy surface for H_2Si_2 isomers explored with complete basis set ab initio method" [J. Mol. Struct. (Theochem) 459 (1999) 221-228]," *The Journal of Molecular Structure: THEOCHEM*, **571**, 231–232, (2001).

38) Swihart, M.T, and L. Catoire, "Reactions in the Al-H-Cl System Studied by ab Initio Molecular Orbital and Density Functional Methods," *The Journal of Physical Chemistry A*, **105**, 264–273 (2001).

39) Bhandarkar, U.V., M.T. Swihart, S.L. Girshick and U.R. Kortshagen, "Modeling of Silicon Hydride Clustering in a Low Pressure Silane Plasma," *The Journal of Physics D: Applied Physics*, **33**, 2731–2746 (2000).

40) Swihart, M.T., "Electron Affinities of Selected Hydrogenated Silicon Clusters (Si_xH_y, x = 1-7, y = 0-15) from Density Functional Theory Calculations," *The Journal of Physical Chemistry A*, **104**, 6083–6087 (2000).

41) Girshick, S.L., M. T. Swihart, S.-M. Suh, M. R. Mahajan and S. Nijhawan, "Numerical Modeling of Gas-Phase Nucleation and Particle Growth during Chemical Vapor Deposition of Silicon," *The Journal of the Electrochemical Society*, **147**, 2303–2311 (2000).

42) Swihart, M.T. and L. Catoire, "Thermochemistry of Aluminum Species for Combustion Modeling from *Ab Initio* Molecular Orbital Calculations," *Combustion and Flame* **121**, 210–222 (2000).

43) Larson, J.M., M.T. Swihart, and S.L. Girshick, "Characterization of the Near-Surface Gas Phase Chemical Environment in Atmospheric Pressure Plasma Chemical Vapor Deposition of Diamond," *Diamond and Related Materials*, **8**, 1863–1874 (1999).

44) Swihart, M. T., and S.L. Girshick, "*Ab Initio* Structures and Energetics of Selected Hydrogenated Silicon Clusters Containing Six to Ten Silicon Atoms," *Chemical Physics Letters*, **307**, 527–532 (1999).

45) Swihart, M.T., and S.L. Girshick, "An Analysis of Flow, Temperature and Chemical Composition Distortion in Gas Sampling through an Orifice during Chemical Vapor Deposition," *Physics of Fluids*, **11**, 821–832 (1999).

46) Swihart, M.T., and S.L. Girshick, "Thermochemistry and Kinetics of Silicon Hydride Cluster formation during Thermal Decomposition of Silane," *The Journal of Physical Chemistry B*, **103**, 64 (1999).

47) Swihart, M.T., and R. W. Carr, "On the Mechanism of Homogeneous Decomposition of the Chlorinated Silanes. Chain Reactions Propagated by Divalent Silicon Species," *The Journal of Physical Chemistry A*, **102**, 1542–1549 (1998).

48) Swihart, M.T., and R.W. Carr, "*Ab Initio* Molecular Orbital Study of the Thermochemistry and Reactions of Chlorinated Disilenes and Their Isomers ($Si_2H_nCl_{4-n}$)," *The Journal of Physical Chemistry A*, **102**, 785–792 (1998).

49) Swihart, M.T., and R.W. Carr, "Thermal Decomposition of Dichlorosilane Investigated by Pulsed Laser Powered Homogeneous Pyrolysis," *The Journal of the Electrochemical Society*, **144**, 4257–4361 (1997).

50) Swihart, M.T., and R.W. Carr, "Thermochemistry and Thermal Decomposition of the Chlorinated Disilanes ($Si_2H_nCl_{6-n}$, n=0-6) Studied by *ab Initio* Molecular Orbital Methods," *The Journal of Physical Chemistry A*, **101**, 7434–7445 (1997).

51) Swihart, M.T., and R.W. Carr, "Pulsed Laser Powered Homogeneous Pyrolysis for Reaction Kinetic Studies: Probe Laser Measurement of Reaction Time and Temperature," *The International Journal of Chemical Kinetics*, **28**, 817–828 (1996).

52) Swihart, M.T., and R.W. Carr, "Pulsed Laser Powered Homogeneous Pyrolysis: A Computational Analysis," *The International Journal of Chemical Kinetics*, **26**, 779–799 (1994).

II. Book Chapters

1) Mark T. Swihart, "Silicon Nanoparticles for Biophotonics," Chapter 4 in *Nanotechnology in Biology and Medicine: Methods, Devices, and Applications*, edited by Tuan Vo Dinh, CRC Press, 2007.

III. Publications in Conference Proceedings:

1) Hongwang Zhang and Mark T. Swihart, "Synthesis of Tellurium Dioxide Nanoparticles by Spray Pyrolysis," *Transactions of the Electrochemical Society*, **2** (7), 239–248 (2006).

2) Hongwang Zhang, Ken-Tye Yong, and Mark T. Swihart, "Synthesis of Zinc Sulfide Nanoparticles by Spray Pyrolysis," *Transactions of the Electrochemical Society*, **2** (7), 249–254 (2006).

3) Hongyi Dang and Mark T. Swihart, "Computational Modeling of Silicon Nanoparticle Formation," *Transactions of the Electrochemical Society*, **2** (7), 255–266 (2006).

4) Mark T. Swihart, Yuanqing He, and Suddha S. Talukdar, "Computational Fluid Dynamics (CFD) Modeling of a Laser-Driven Aerosol Reactor," *Transactions of the Electrochemical Society*, **2** (7), 267–278 (2006).

5) Z. M. Khakimov, P. L. Tereshchuk, N. T. Sulaymanov, F. T. Umarova, A. P. Mukhtarov, and Mark T. Swihart, "Non-Conventional Tight-Binding Molecular Dynamics Simulation of

Bare Silicon and Silicon-Hydrogen Clusters," *Transactions of the Electrochemical Society*, **2** (7), 279–288 (2006).

6) Kim, Sung Jin, V.P. Chodavarapu, F. Kamal, V.K.S. Hsiao, and A.N. Cartwright, "Tunable porous photonic bandgap structures for chemical and biological sensing" *Proceedings of SPIE-The International Society for Optical Engineering* **6322**, 632201 (2006).

7) Swihart, Mark T., "Assembling gas-phase reaction mechanisms for high temperature inorganic systems based on quantum chemistry calculations and reaction rate theories," *Journal of the Chemistry and Physics of Solids*," **66**, 364–371 (2005). Part of a special issue containing the proceedings of The IUPAC Conference on High Temperature Materials Chemistry – XI, May 19–23, 2003, Tokyo, Japan.

8) Kirkey, W.D., A.N. Cartwright, X. Li, Y. He, M.T. Swihart, Y. Sahoo, and P.N. Prasad, "Optical Properties of Polymer-Embedded Silicon Nanoparticles," *Proceedings of the Materials Research Society*, **789**, N.15.30.1–N.15.30.6, (2004).

9) Goodarzi, A., Y. Sahoo, M.T. Swihart, and P.N. Prasad, "Aqueous Ferrofluid of Citric Acid Coated Magnetite Particles," *Proceedings of the Materials Research Society*, **789**, N.6.6.1–N.6.6.6, (2004).

10) Li, X., Y. He, S.S. Talukdar, M.T. Swihart, "Preparation of luminescent silicon nanoparticles by photothermal aerosol synthesis followed by acid etching," *Phase Transitions: A Multinational Journal*, **77**, 131–137 (2004). Part of a special issue containing proceedings of the International Symposium on Structure and Dynamics of Heterogeneous Systems, Gerhard-Mercator-Universität Duisburg, November 29, 2002, Duisburg, Germany.

11) Swihart, M.T., X. Li, Y. He, W.D. Kirkey, A.N. Cartwright, Y. Sahoo, and P.N. Prasad, "High-rate synthesis and characterization of brightly luminescent silicon nanoparticles with applications in hybrid materials for photonics and biophotonics" *Proceedings of SPIE-The International Society for Optical Engineering* **5222**, 108–117 (2003)

12) Cartwright, A.N., W.D. Kirkey, M.L. Furis, X. Li, Y. He, D. MacRae, Y. Sahoo, M.T. Swihart, and P.N. Prasad, "Ultrafast dynamics in nanostructured materials," *Proceedings of SPIE-The International Society for Optical Engineering* **5222**, 134–139 (2003).

13) S.S. Talukdar, C.A. Ng, and M.T. Swihart, "Aerosol Dynamics Modeling and Computational Fluid Dynamics of a Laser-Driven Nanoparticle Synthesis Reactor," *Proceedings of the Electrochemical Society*, **PV 2003-08**, 235–242 (2003).

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20) Li, X, and M.T. Swihart, "Modeling Particle Nucleation during Thermal CVD of Silicon from Silane using Kinetic Monte Carlo Simulation," *Proceedings of the Electrochemical Society*, **2000-13**, 60–66 (2000).

21) Bhandarkar, U.V., M.T. Swihart, U.R. Kortshagen, and S.L. Girshick, "Modeling of Plasma Chemistry for Silicon Hydride Clustering in PECVD Processes," Proceedings of the 14th International Symposium on Plasma Chemistry (Institute of Plasma Physics AS CR; Prague, Czech Republic, August 2–6, 1999) vol. IV, pp. 2205–2210.

22) Kortshagen, U.R., U.V. Bhandarkar, M.T. Swihart, and S.L. Girshick, "Generation and Growth of Nanoparticles in Low-Pressure Plasmas," *Pure and Applied Chemistry*, **71**, 1871–1877 (1999).

23) Girshick, S.L., M.T. Swihart, S.-M. Suh, M.R. Mahajan, and S. Nijhawan, "Numerical Modeling of Gas-Phase Nucleation and Particle Growth during Chemical Vapor Deposition of Silicon," *Proceedings of the Electrochemical Society*, **98-23**, 215–226 (1999).

IV. Invited Presentations

1) Swihart, M.T., "Better Living through Nanomaterials: Past, Present, and Future," UB Department of Electrical Engineering, January 27, 2006.

2) Swihart, M.T., "Preparation of Organically-Capped Silicon Quantum Dots," Brockhouse Institute for Materials Research, McMaster University, Ontario, Canada, November 14, 2005.

3) Swihart, M.T., "Vapor-Phase Synthesis of Nanoparticles," China/USA/Japan Joint Chemical Engineering Conference, Beijing, China, October 14, 2005.

4) Swihart, M.T., "Better Living through Nanomaterials: Past, Present, and Future," UB This Summer Lecture Series, June 16, 2005.

5) Swihart, M.T., "Production and Surface Functionalization of Macroscopic Quantities of Brightly Photoluminescent Silicon Nanoparticles and Magnetic Metal Nanoparticles," ECI Conference on "Nanoparticles from the Vapor Phase with Chemical and Biochemical Applications," Davos, Switzerland, August 10, 2004.

6) Li, X., Y. He, and M.T. Swihart, “Production and surface functionalization of macroscopic quantities of brightly photoluminescent silicon nanoparticles,” University of Minnesota, IGERT program in nanoparticle technology, March 26, 2004.

7) Li, X., Y. He, and M.T. Swihart, “Production and surface functionalization of macroscopic quantities of brightly photoluminescent silicon nanoparticles,” Dow Corning Corporation, Midland, MI, February 16, 2004.

8) Swihart, M.T., “J.B. Wagner Award Address: Assembling Gas-Phase Reaction Mechanisms for High Temperature Inorganic Systems Based on Quantum Chemistry Calculations and Reaction Rate Theories,” 204th meeting of the Electrochemical Society, October 14, 2003, Orlando, Florida.

9) Swihart, M.T., “High-Rate Synthesis and Characterization of Brightly Luminescent Silicon Nanoparticles with Applications in Hybrid Materials for Photonics and Biophotonics,” presented at a symposium entitled "Organic and Hybrid Materials for Nanophotonics" at the 48th Annual Meeting of the SPIE, August 4–5, 2003, San Diego, California.

10) Swihart, M.T., “Assembling Gas-Phase Reaction Mechanisms for High Temperature Inorganic Systems Based on Quantum Chemistry Calculations and Reaction Rate Theories,” presented as an *invited keynote lecture* at The IUPAC Conference on High Temperature Materials Chemistry – XI, May 19–23, 2003, Tokyo, Japan.

11) Swihart, M.T., “Preparing and Functionalizing Macroscopic Quantities of Brightly Photoluminescent Silicon Nanoparticles with Emission Spanning the Visible Spectrum,” May 20, 2003, Department of Chemical Systems Engineering, University of Tokyo.

12) Swihart, M.T., "High-Rate Synthesis, Characterization, and Potential Applications of Brightly Luminescent Silicon Nanoparticles,” at the International Symposium on Structure and Dynamics of Heterogeneous Systems, Gerhard-Mercator-Universität Duisburg, November 29, 2002, Duisburg, Germany.

13) Swihart, M.T., “Experimental and Modeling Studies on the Nucleation and Growth of Silicon Nanoparticles from the Vapor Phase,” IT Collaboratory Teleconference Series, Held at University at Buffalo and broadcast to Rochester Institute of Technology and Alfred University, January, 2002.

14) Swihart, M.T., “Experimental and Modeling Studies on the Nucleation and Growth of Silicon Nanoparticles from the Vapor Phase,” Department of Electrical Engineering, University at Buffalo, April, 2002.

15) Swihart, M.T. "Chemical Kinetic Studies of the Homogeneous Chemical Nucleation of Silicon Nanoparticles,” at a workshop entitled "Precursor materials, clusters and nanoparticles: Experiment and theory,” Gerhard-Mercator-Universität Duisburg, October 5, 2000, Duisburg, Germany.

Presenter and/or co-author on contributed talks and posters at conferences including meetings of The Electrochemical Society (ECS), The American Institute of Chemical Engineers (AIChE), the Biomedical Engineering Society, the American Association for Aerosol Research (AAAR), The International Aerosol Conference, Gordon Conferences, the International Conference on Plasma

Chemistry, Materials Research Society Symposia, the APS Gaseous Electronics Conference, and the International Symposium on Nanoparticles: Aerosols and Materials (July 2001, Pusan, Korea).

V. Patents and Patent Applications

1) Yong, Ken-Tye, Yudhisthira Sahoo, Mark T. Swihart, and Paras N. Prasad, "Facile High-Yield Production of Semiconductor Quantum Rods and Multipods using Noble Metal Nanoparticles," pending application, submitted December 21, 2006.

2) Ruckenstein, Eli, Mark T. Swihart, and Fengjun Hua, "Production of Photoluminescent Silicon Nanoparticles having Surfaces that are Essentially Free of Residual Oxygen," pending application, serial number 60/672,808, filed April 19, 2006.

3) He, Yuanqing, Xuegeng Li, and Mark T. Swihart, "Production of Nickel Nanoparticles from Nickel Carbonyl via Laser Pyrolysis," pending application, serial number 60/618,288, filed October 13, 2005. Exclusive license from UB to INCO of Toronto, Canada executed May 2005.

4) Li, Xuegeng, Yuanqing He, and Mark T. Swihart, "Process for Producing Luminescent Silicon Nanoparticles," pending application, Serial No. 10/796,442, filed March 9, 2004.

5) Becker, C.L., J.R. Lattner, and M.T. Swihart, "Fluidized Bed Reactor and Process," U.S. Patent No. 6,627,068 (2003).

6) Becker, C.L., J.R. Lattner, and M.T. Swihart, "Fluidized Bed Reactor and Process for Producing 5-Ethylidene-2-Norbornene," U.S. Patent No. 6,294,707 (2001).

ORGANIZATIONAL MEMBERSHIPS

Member, The Electrochemical Society (ECS), American Institute of Chemical Engineers (AIChE), The American Association for the Advancement of Science (AAAS), The American Chemical Society (ACS), The American Association for Aerosol Research (AAAR), The Materials Research Society (MRS), Tau Beta Pi, Phi Beta Kappa, and Sigma Xi

PROFESSIONAL AND PUBLIC SERVICE

Reviewer for *Science, Advanced Materials, Journal of the American Chemical Society, Nano Letters, Advanced Functional Materials, Chemistry of Materials, Langmuir, The Journal of Physical Chemistry (A and B)*, *Industrial and Engineering Chemistry Research, The Journal of Chemical Physics, The Journal of the Electrochemical Society, The Journal of Materials Science, Chemical Vapor Deposition, The International Journal of Chemical Kinetics, The Journal of Crystal Growth, The Journal of Computational Chemistry, Journal de Physique IV*, *The Journal of Aerosol Science*, *Aerosol Science and Technology, The Journal of Nanoparticle Research, Surface Science, Physica E, The Journal of Nanophotonics* and *Applied Physics A*.

Proposal reviewer/panelist for The National Science Foundation, the ACS Petroleum Research Fund, The Swiss Federal Institute of Technology (ETH), and The U.S. Civilian Research and Development Foundation.

Lead organizer and proceedings editor for "The Second International Symposium on Fundamental Gas-Phase and Surface Chemistry of Vapor-Phase Materials Processing," held at the Electrochemical Society National Meeting, March 2001, Washington, D.C.

Lead organizer and proceedings editor for "The Third International Symposium on Fundamental Gas-Phase and Surface Chemistry of Vapor-Phase Materials Processing," held at the 209th Meeting of The Electrochemical Society, May 2006, Denver, Colorado.

Co-chair or chair of one or two sessions each year at the AIChE fall annual meeting.

Member of the Organizing Committee for CVD-XVI/EUROCVD 14, held April 28–May 3, 2003 in Paris, France, in conjunction with the 203rd meeting of the Electrochemical Society.

Member of the Executive Committee of the High Temperature Materials division of the Electrochemical Society, 1999–present.

Member of the Editorial Advisory Board of the *International Journal of Chemical Kinetics*, 2001–2004.

Founding Member of the Editorial Board of *NanoBiotechnology*, published by Humana Press.

FORMAL TEACHING ACTIVITIES

Fall 2006:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 20 students).

- Had full responsibility for required, core graduate course in chemical kinetics and reaction engineering.

Spring 2006:

Instructor, CE 304, Chemical Engineering Thermodynamics, University at Buffalo, (4 credits, enrollment: 44 students).

- Had full responsibility for required, core undergraduate course in chemical engineering thermodynamics.

Spring 2005:

Instructor, CE 304, Chemical Engineering Thermodynamics, University at Buffalo, (4 credits, enrollment: 46 students).

- Had full responsibility for required, core undergraduate course in chemical engineering thermodynamics.

- Introduced, in collaboration with David Kofke and staff from the Center for Technical Communications, a major technical writing assignment based on a ‘virtual experiment’ carried out using molecular simulations.

Instructor, CE 456/556, Introduction to Aerosol Science and Technology, University at Buffalo, (3 credits, enrollment: 20 students).

- Taught this dual-listed undergraduate/graduate course for the second time. It was previously offered as CE412/512 (a special topics course number) as described below.

Fall 2004:

Advisor, CE 406 SWI, AIChE Student Chapter ‘Chem-E-Car Competition’, University at Buffalo, (3 credits, enrollment: 16 students).

Spring 2004:

Instructor, CE 304, Chemical Engineering Thermodynamics, University at Buffalo, (4 credits, enrollment: 61 students).

- Had full responsibility for required, core undergraduate course in chemical engineering thermodynamics.

- Developed course web page including typed course notes, almost 200 additional pages of solved problems, and various other resources.

- Actively used the course web page and various computer demonstrations during lectures, which were given in a 'technology' classroom with computer projection facilities.

Instructor, CE 512, Chemically Reacting Flows, University at Buffalo, (3 credits, enrollment: 6 students).

- Developed an entirely new elective course at the advanced graduate level.

Fall 2003:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 18 students).

- Had full responsibility for required, core graduate course in chemical kinetics and reaction engineering.

- Developed (from 1998–2003) new course notes, incorporating microscopic views of kinetics and modern computer-based methods of analysis for both chemical kinetics and detailed modeling of complex reactors.

- Developed (from 1998–2003) course web page including over 300 typed pages of course notes, almost 200 additional pages of solved problems, and various other resources.

- Actively used the course web page and various computer demonstrations during lectures, which were given in a 'technology' classroom with computer projection facilities.

Advisor, CE 406 SWI, AIChE Student Chapter 'Chem-E-Car Competition, University at Buffalo, (3 credits, enrollment: 11 students).

Spring 2003:

Instructor, CE 304, Chemical Engineering Thermodynamics, University at Buffalo, (4 credits, enrollment: 39 students).

Instructor, CE 412/512, Introduction to Aerosol Science and Technology, University at Buffalo, (3 credits, enrollment: 30 students).

- Developed an entirely new elective course at the senior undergraduate/first-year graduate level.
- Developed course web page including typed course notes, solved problems, and various other resources.
- Brought the entire class to my research laboratory for a demonstration of modern aerosol science instrumentation, and also gave several simpler in-class demonstrations.

Fall 2002:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 15 students).

Advisor, CE 406 SWI, AIChE Student Chapter 'Chem-E-Car Competition, University at Buffalo, (3 credits, enrollment: 7 students).

Spring 2002:

Instructor, CE 304, Chemical Engineering Thermodynamics, University at Buffalo, (4 credits, enrollment: 47 students).

Fall 2001:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 21 students).

Spring 2001:

Instructor, CE 328, Chemical Engineering Laboratory II, University at Buffalo, (1 credit, enrollment: 50 students).

- Re-structured laboratory experiments to include computer-aided data acquisition using graphical programming in the LabView data acquisition environment.
- Developed and applied a rubric-based assessment system for measuring student performance.

Fall 2000:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 10 students).

Spring 2000:

Instructor, CE 328, Chemical Engineering Laboratory II, University at Buffalo, (1 credit, enrollment: 38 students).

Advisor, CE 406 SWI, AIChE Student Chapter Team Competition, University at Buffalo, (3 credits, enrollment: 20 students).

Instructor, CE 502 SWI, Introduction to Matlab and Maple for Scientific Problem Solving, University at Buffalo, (1 credit, enrollment: 6 students).

Fall 1999:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 20 students).

Spring 1999:

Instructor, CE 328, Chemical Engineering Laboratory II, University at Buffalo, (1 credit, enrollment: 52 students).

Advisor, CE 406 SWI, AIChE Student Chapter Environmental Design Contest, University at Buffalo, (3 credits, enrollment: 13 students).

Instructor, CE 502 SWI, Introduction to Matlab and Maple for Scientific Problem Solving, University at Buffalo, (1 credit, enrollment: 7 students).

Fall 1998:

Instructor, CE 561, Applied Chemical Kinetics, University at Buffalo, (4 credits, enrollment: 22 students).